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ABSTRACT

Computer managed instruction (CMI) is essentially an information system capable of deciding on performance expectations and appropriate educational experiences. In addition to the two decision processes, five major processes are viewed as being central to the man-machine system of CMI: test scoring, achievement profiling, diagnosing, prescribing, and instructing. Thus computer-assisted instruction can be just one facet of a computer managed instruction program. Most CMI systems are built around units of instruction that are specified in terms of educational objectives desired student behavior, levels of competence, and/or concepts to be learned. Generally, the similarities of CMI programs are greater than their differences. The WIS-SIM model for CMI, developed by the Wisconsin R & D Center, embodies most of these features. Individually guided education is the ultimate in flexible, non-linear education programs and is well suited to CMI. An added benefit of CMI is the use of the data field to generate information for decisions on whole programs not just units. (WH)

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CMI THEORY AND APPLICATION IN CLASSROOM
DECISION-MAKING

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of

The Wisconsin Educational Research Association

by

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Individualization of instruction is not a new concept in the field of education; for many years there has been considerable interest in and support for individualized education (Whipple, 1925, Henry, 1962, Klausmeier, et al., 1971). Though approaches, materials, and programs have varied, there is a continuing focus on the individual student and his capabilities. Both commercial and private interests have entered the push to individualize education. Continued interest in defining and meeting the personal, social, and educational needs of each student has been the calling card and goal of many educators and educational groups. This movement can be traced from Plato to 1974.

A common problem of all individualization programs has been the inability of teachers, clerical staff, and administrators to deal effectively with the great volumes of record-keeping and processing necessary to individualize education. While this problem might not have bothered Plato and his immediate successors, as populations grew and interest in education blossomed, the weight of numbers of students, and bits of data known about each, overwhelmed the school's ability to manage individualization of education. Individualized education was constrained. It is the purpose of this paper to present and propose a computer management system for education which would relieve students, teachers, and administrators of much of the clerical work and record-keeping which stands as a drawback to individualized education. It can provide the information necessary to instructional decision-making.

Since the commercial development of digital computers in the early 1950's, there have been many attempts to bring these data processing capabilities to education (Kaimann and Marker, 1967, Johnson, 1971, Baker, 1971, Belt and Spuck, in press). The computer has been used effectively in education to assist in clerical and bookkeeping functions such as payroll, inventory, and student scheduling and grade reporting. More recently, the computer is being used to assist educational decision-making by collecting, summarizing, and reporting information. Educational decisions have too often been made without proper background information, not because the information was unavailable, but because much of the information was both difficult to access and in unusable formats. The computer processing capability can aggregate, sort, collate, and present large amounts of data in usable formats at appropriate times. A most crucial problem of individualized education has begun to be formally approached through systems of computer managed instruction (CMI). Without belabouring this paper with a listing of those CMI systems developed or being developed, the interested reader is directed to Dr. Frank Baker's excellent review as found in the Review of Educational Research, Vol. 41, 1971.

A system of computer managed instruction, CMI, has as its objectives the collecting and processing of student information and supplying this information at appropriate times and places so that it is directly applicable to instructional decision-making (Belt and Spuck, in press). When the appropriate information is supplied to decision-makers in a usable format, efficiency and quality of decisions made can rise. ". . . the primary function of the computer in a CMI system is to make possible more complicated decision processes than would be possible without the computer, and to do this on a continuous basis" (Cooley and Glaser, 1968). The teacher, student, and administrator continuously need information through which they can evaluate instructional decision situations.

CMI concepts and practices go beyond traditional student accounting. This is a result of the growing evidence which indicates that the strength of a management system is in assisting school systems to alter their instruction programs while maintaining necessary command (Bolton and Clark). It is, then, the purpose of a CMI system to utilize the computer to optimize the learning environment for each child and to maximize the efficient use of school resources: human, financial, and material. The system is so designed that it becomes a man-machine system focused on individualized instruction.

Computer Managed Instruction (CMI) is not to be confused with Computer Aided Instruction (CAI). CAI systems are designed to be a means of instruction in which the student is on-line to a computer through an interactive terminal. In such systems, information and/or stimulus material is presented to the student, student responses are accepted and processed, feedback is provided the student, and the computer maintains various degrees of control over the sequencing of material. Specific categories of such interactive instruction include tutoring, drill and practice, case study, gaming and laboratory simulation. Contrary to commonly known CAI systems, machine/student interface is generally not a part of a computer managed instruction. Since the drill and practice aspects of CAI can be both a valuable student activity and a source of input of student information, CAI can be considered as a subset of a complete CMI system; that is, the prescriptions for instruction made within the framework of a CMI system may well include CAI along with other instructional approaches and CAI may well result in achievement information useful in assessing mastery. The main objective of CMI is collecting and processing performance information for each student and making this available to school personnel in order to assist in making appropriate instructional decisions.

In contrast with Computer Assisted Instruction (CAI), where the computer program, through direct participation with the student, "would present instructional materials to the student, collect his responses, analyze them, and select the next step to be performed by the student" (Baker, 1971), CMI is a system through which the computer and the instructional team - teachers, principals, district administrators - cooperate to administer and guide the instructional process. The computer, then, is less a teaching machine and more an information system.

As mentioned above, a number of CMI systems currently exist. According to a recent survey, the characteristics of these systems were examined and a great deal of similarity was noted among them. This survey showed that, generally, each of the various CMI systems are built around units of instruction that are specified in terms of educational objectives, desired student behavior, levels of competence, and/or concepts to be learned. Associated with each instructional unit are criterion-referenced tests for each objective in that unit which assess level of mastery. Typically, such tests are administered as pretests to determine a student's present level of achievement and as post-tests to determine if specific objectives have been achieved.

The several CMI projects differ in three primary areas: 1) Their reliance upon existing instructional materials or creating new resources; 2) Their academic level and area of study; 3) The latitude of prescriptive information generated. However, their similarities are even greater than their differences. All are based on carefully conceived and specified performance objectives. And all CMI systems process objectives and the performance upon them into some degree of instructional prescription. The literature reveals four major functions are performed by computers in CMI applications: test scoring, diagnosing, prescribing, and reporting (Baker, 1971). Typically, a pretest which is computer scored is taken by each pupil at the beginning of each unit of instruction to determine his status relative to instructional objectives. On the basis of the pretest results, the pupil is assigned specific learning tasks. The prescribed tasks can be any of a number of educational experiences, but in most instances, the result is a student engaging by himself in an educational experience such as seat work, reading books, Computer Aided Instruction, or working with some audio-visual material. At various points within a unit, the pupil may take diagnostic or progress tests that may be computer scored, and which access his progress toward specific objectives contained within the unit. Reports are generated based on the test results which indicate whether the student is meeting the objectives assigned to him. When the pupil has completed the assigned tasks, he takes a criterion-referenced post-test. If the student does not demonstrate mastery of certain educational objectives, he is assigned alternate remedial work. After a unit has been completed, the basic pattern of pretest, diagnosis, prescription, and post-test is repeated for each unit of instruction. In some systems, a post-test may serve as a pretest for a subsequent unit. Within these general characteristics, the several various ongoing CMI projects differ only in detail or emphasis upon the prescriptive aspects of the system. Rudimentary prescriptive procedures are part of most CMI systems, but the amount of detail in the prescriptions vary (Baker, 1971). In some systems the test score obtained by the student will be translated by the computer program into a folder number, text chapter, or lesson. Other systems use tests as mechanisms for grouping students with similar needs from which the teacher can make prescriptive decisions.

The general model for CMI systems under development through the Wisconsin Research and Development Center is conceptualized, as shown in Figure 1. The WIS-SIM model depicts the two major decision areas, specifying performance expectations and selecting appropriate educational experiences, as diamonds in the figure. Five major processes, in addition to the two decision processes, are viewed as being central to the man-machine system of computer managed instruction: test scoring, achievement profiling, diagnosing, prescribing, and instructing. These processes form a loop, indicating their cyclic nature in the system (Belt and Spuck, in press).

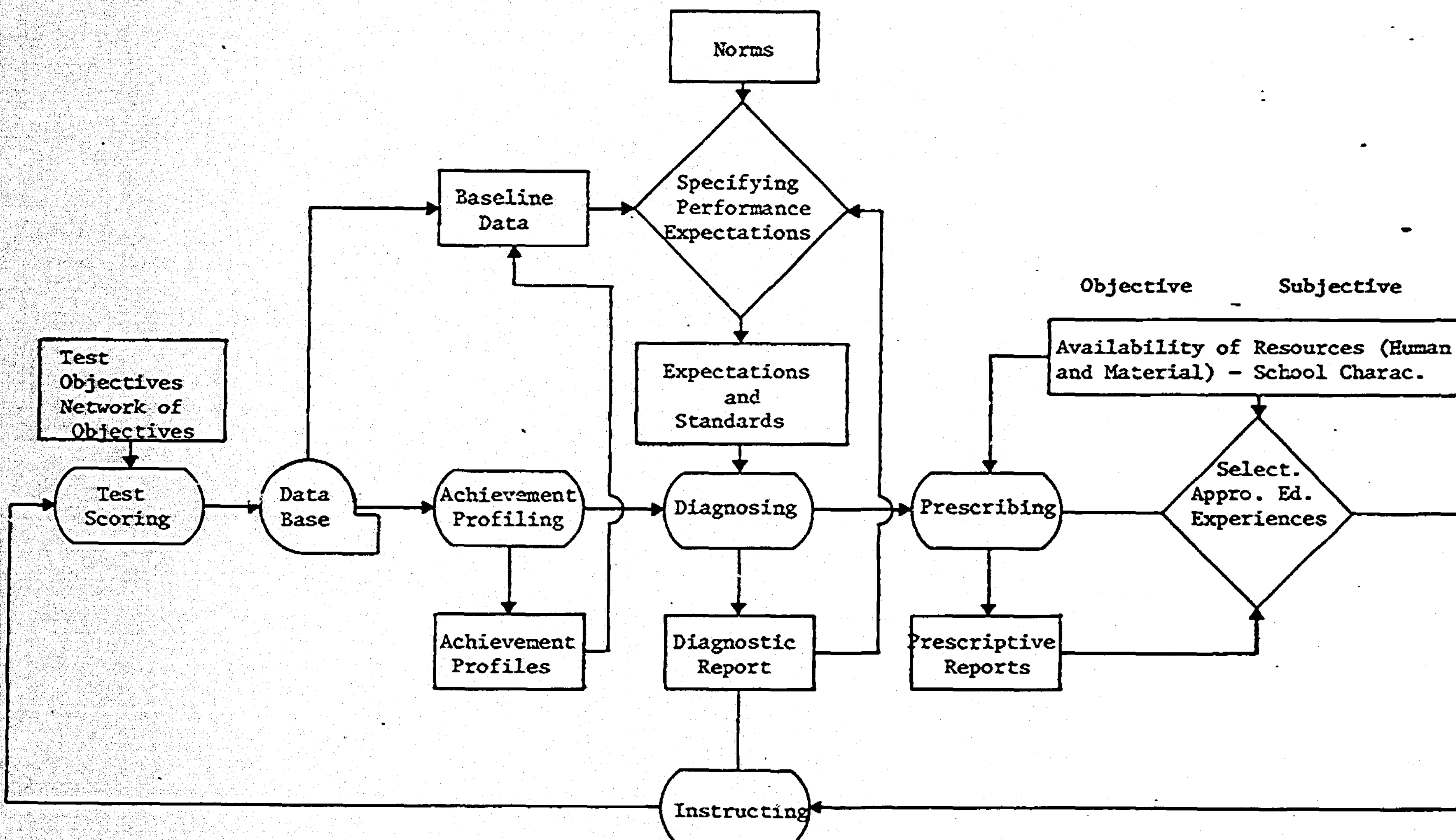
Before the general model for CMI systems is discussed, definitions for some of the terms used would be appropriate.

1) <u>Data Base and Baseline Data</u> - the Data Base, as conceptualized in a CMI system, contains these types of information: background demographic information on each student, curriculum objectives, and assessments of student achievement.

2) <u>Testing</u> - In order to initialize the Data Base relative to student achievement, a preassessment generally takes place. The achievement level of each student, relative to the objectives specified in the curriculum, may be

Figure 1

Model of System
for Instructional Management



derived from these preassessments and post-tests after each completed objective. A body of achievement level reports builds up over instructional experiences and assessments.

3) <u>Achievement Profiling</u> - A report is produced summarizing the progress of an individual student across all instructional objectives in the curriculum area or a summary of the performance of a group of students across a group of objectives. This report shows the placement in the instructional program of students at the time of the report. These reports may be used in the same way that traditional grade reports are used: feedback to parents and students, and as input to parent, teacher, and student conferences. Achievement profiles may also be produced at the school and district levels; these profiles may be summaries by unit of the number of students reaching mastery on each objective. It should be noted that achievement profiles summarize achievement in comparison to the prespecified mastery levels.

4) <u>Diagnosing</u> - The function of diagnosis within CMI, and specifically WIS-SIM, is to compare achievement information, defined as level(s) of mastery, with pre-established performance expectations. A low level of diagnosis is to identify those objectives which the student has mastered and to identify those objectives which the student has not mastered. Such reports, if produced, would be diagnostic reports - diagnostic in the sense that they identify student needs. The performance expectations in this case are the prespecified mastery levels entered into the data base. This type of diagnostic report differs little from achievement profiles.

Through the decision of specifying performance expectations, specific expectations and standards result. These expectations serve as input to the diagnosis process. Diagnosis, then, is the process of comparing the individual student's achievement record, in terms of level(s) of mastery across objectives, with the expectations and standards established for that student. Reports may be developed which present the results of these comparisons for each student to decision-makers, but more important and more useful are reports which indicate those students whose achievement levels are greatly out of tolerance with respect to the expectations and/or standards. These exception reports flag the students who may need extra consideration in instructional programming through one-to-one instruction, or the use of supportive personnel such as reading specialists or social workers. Diagnosis reports also could be used to identify students who are moving rapidly through the objectives for use in tutoring situations with other students.

5) Prescribing - The need for computer managed instructional systems is based in their ability to assist teachers in the effective implementation of programs of individualizing instruction. Nothing presented thus far in the discussion of CMI has provided for an individualized instructional program. While diagnosis and achievement profiling take place on an individual level, it is the prescribing function, the associated decision of selecting appropriate educational experiences and the subsequent instructing function which individualizes the educational program.

The prescribing function of CMI systems utilizes the input which results from the diagnostic function and formulates a prescription or alternative prescriptions which are deemed appropriate to meet the needs identified by the diagnosis. The objectives which have not yet been mastered by the student are searched relative to prerequisites which may exist, and prescriptions result which are considered "best" according to programmed criteria. In many systems, the teacher reviews the prescription and makes the final decision as to the "best" instruction prescription.

Individualization of instruction takes place in a variety of forms. Some programs allow students to proceed independently at their own pace through the instructional objectives of the program. Upon completion of an objective or an objective set, testing and diagnosis take place and a new instructional activity, directed toward the next objective, is prescribed. Many programs which allow this type of individualization are linear in nature; that is, instructional objectives may be ordered from 1 to N and as the student masters objective 1, he begins objective 2, and so on. Other programs present alternative instructional activities and allow for students and/or teachers to make the final selection as to what next activity should be implemented. Many of these systems generate prescriptions which refer the student to programmed materials, work books, file folders, or texts, or possibly the teacher.

Individually Guided Education is a system of individualization or student grouping by student needs which is under research at the Wisconsin R & D Center. It lends itself well to a mating with CMI. Individually Guided Education specifies that an instructional program should be planned and implemented for each student which varies a) the amount of attention and guidance by the teacher, b) the amount of time spent in interaction among students, c) the use of printed materials, d) the use of space and equipment (media), and e) the amount of time spent by each student in one-to-one with the teacher or media, independent study, adult or student-led small group activities, and adult-led large group activities. This view of instructional individualization is a clear departure from the "file folder" approach. It is in the prescription process, then, that WIS-SIM takes on its unique characteristics. Prescribing within the context of IGE not only involves the notions of independent study and grouping students with common needs together in instructional settings, but it also recognizes the subjective inputs to instruction which cannot, at this point in CMI development, be programmed. Special teacher skills or weaknesses, student learning idiosyncracies, personality interactions (both positive and negative), and spacial considerations are all examples of subjective input to the prescribing process which WIS-SIM recognizes as important. It is an ongoing goal of WIS-SIM to develop machine formulated prescriptions which take as many of these factors as possible into consideration. The objective being to select educational experiences for the student which maximize educational benefit while considering the availability of human, material, and financial resources.

To place this view of CMI in a more practical setting, a computer management application to the Wisconsin Design for Reading Skill Development (WDRSD) will be cited for purposes of examples (Belt and Giroux, in press). Within WDRSD, which is an IGE program, the focus is upon specific reading skills, assessment of student needs, and the management and monitoring of student progress towards these skills. In practical terms, the major decision is to select from available instructional experiences the one that appears to be most appropriate for specific students or groups of students. Though the educational experiences within IGE cover a broad spectrum, the most frequently varied factor is the instructional group size; from one student to large lecture. While the formation of large lecture groups requires a minimum of information, the creation of small, specialized instructional groups requires current diagnostic information for individual students, curriculum objective sequencing, and availability of teachers, space, materials, and time. From this broad range of specific information bits, a prescription for both student grouping and activities selection can be made (Belt and Spuck, in press). CMI as an information system can supply this necessary volume of data through a series of reports generated periodically or upon request. Examples of these reports are:

1) The Specific Grouping Report which presents all students in the school who are working or could be working on a specified objective (Figure 2);

2) The Unit Performance Profile which lists all students in the school who are working on a specified unit and which objectives they have completed (Figure 3);

3) The Diagnostic Report lists students who have not mastored any skill for six or more weeks, the last skill mastered, and the date of that mastery -- noting

that skills are designed to be mastered within a week (Figures 4 and 5). Further, there is a Diagnostic Report which lists students who deviated from the expected number of skills mastered by two or more skills. This report identifies both those who have completed more skills and those who are falling behind expectations. The collection, processing, and timely reporting of the masses of data necessary to these diagnostic reports is the function of a CMI, specifically WIS-SIM, system. This information system should lead to better prescriptive decisions and, thereby, optimizing the educational benefits for each child while making efficient use of all the school's resources. WIS-SIM is conceptualized to provide this appropriate and timely information to decision-makers. It, like all CMI systems, makes several assumptions relative to the measurability of specified educational objectives and the existence of appropriate assessment instruments. It is necessary here only to recognize that these assumptions are made.

Unique WIS-SIM features include the major role of the exception report, which is, in effect, a grouping report, and the active recognition of the value of both objective and subjective input to the prescribing process and the grouping decisions. As the state of the CMI art improves, what is now entered as subjective may well become an objective bit of data input. WIS-SIM recognizes this as an important facet of the information flow to decision-making.

While the major thrust of WIS-SIM and some other computer managed instructional systems is directed at providing information to decision-makers at the unit level, it has been noted that reports may be generated for use by decision-makers at the IIC and SPC levels. These reports are used in making decisions related to the effective implementation of the instructional program at the school or district level.

The information stored in the CMI data base is a detailed historical account of student achievement in the included instructional areas. This information,

Figure 2

SCHOOL: UNION

UNIT:

SPECIFIC GROUPING REPORT

AS OF 11/13/73

WISCONSIN DESIGN FOR READING SKILL DEVELOPMENT

GROUPING FOR SKILL B5 -- WORD ATTACK SKILLS

PREREQUISITE MASTERY - ALL A SKILLS AND B3 AND B4

STUDENT NO.	STUDENT NAME	GRADE	ATTEMPTS	DATE OF LAST ATTEMPT	LAST %
0375	JAMES CALDER	01			
0685	OMER DOYLE	01			
0980	JOHN SCOTT	01	1	09-23-73	65
1030	RUTH CHASE	01			
1135	RORY JAMES	01			
1175	RICHARD NOLEN	01	1	10-09-73	75
1350	JERRY LYNCH	01			
1515	BOBBY TRANE	01			
1605	ROBERT DOTT	01	1	09-02-73	75
0030	DAVID TRICE	02	1	09-16-73	60
0090	ALICE MOLZAHN	02	1	09-23-73	60
0230	MARGARET SMITH	02	1	09-23-73	60
0360	JESSICA CURTIS	02			
1740	JOYCE ALLEMAND	02	1	09-16-73	75
0795	LISA KRUGER	02	1	09-02-73	40
1040	JANE RAHN	02			
1125	ART BRAGUE	02	1	09-09-73	25
0747	PATRICIA SUELLEN	03			

Figure 3

SCHOOL: DAVIDSON ELEMENTARY

UNIT: M

UNIT PERFORMANCE PROFILE

AS OF 2/10/73

WISCONSIN DESIGN FOR READING SKILL DEVELOPMENT

WORD ATTACK

NUMBER	NAME	A1	A2	A3	A4	A5	A6	ALL A MASTERY	B1	B2	B3>	B4>	B5	B6	B7	B5 ↓ B8	B9	B10	B11>	B12>	B13	ALL B MASTERY
0035	ABBOTT, WILLIAM A.							M	M	M	M	M	M	M	60	M	53	20	M	M	M	
0075	ALDER, PATRICIA A.							M	M	NM	M	M	M	M	53	M	53	20	67	50	15	
0130	ALEXANDER, JOHN T.							M														M
0190	BARNES, PATRICIA L.							M														M
0205	BILLINGSLEY, LAURA A.							M														M
0320	DEBOER, ROGER							M	M	NM	M	60	M	M	40	35	35	33	M	M	35	
0335	DELANEY, JANET R.							M														M
0340	FRANKEL, STEVEN							M	NM	NM	M	M	M	35	40	M	53	40	33	M	35	
0415	FRUSHER, KITTY							M	M	M	M	M	M	40	M	M	M	M	M	M	M	
0420	FULLER, TIMOTHY K.							M														M
0535	GEMPELER, THOMAS Q.							M	M	M	M	M	M	M	M	M	M	53	67	M	M	
0640	HARRINGTON, MATHEW J.							M	M	NM	M	M	M	50	53	M	18	27	25	M	M	
0775	JOHNSTON, SANDRA A.							M														M
0845	JONES, FRANK I.							M														M
0900	LAPRUZZO, ANTOINETTE							M														M

Figure 4

SCHOOL: LAKEWOOD ELEMENTARY
TEACHER: E. BROWNING

DIAGNOSTIC REPORT

AS OF MARCH 2, 1973

WISCONSIN DESIGN FOR READING SKILL DEVELOPMENT

STUDENTS WHO HAVE NOT MASTERED A SKILL FOR SIX OR MORE WEEKS

NUMBER	NAME	LAST SKILL MASTERED	DATE
1358	DAVIS, MICHAEL T.	B-8	DECEMBER 15, 1972
1236	DENTON, JAMES S.	B-10	JANUARY 19, 1973
1379	LEHMANN, DENNIS P.	C-1	JANUARY 19, 1973
1204	NASH, KIRSTIN M.	C-2	JANUARY 12, 1973
1362	REMINGTON, ELIZABETH R.	C-1	JANUARY 19, 1973

Figure 5

HOOL: NORTHBROOK ELEMENTARY
ACHER: J. SEVERSON

DIAGNOSTIC REPORT

AS OF JANUARY 3, 1973

WISCONSIN DESIGN FOR READING SKILL DEVELOPMENT

STUDENTS WHO HAVE DEVIATED FROM ANTICIPATED NUMBER
OF FIRST SEMESTER SKILLS BY TWO OR MORE

NUMBER	NAME	ANTICIPATED # OF SKILLS TO BE MASTERED 1ST SEMESTER	ACTUAL # OF SKILLS MASTERED	DIFFERENCE BETWEEN ANTICIPATED AND ACTUAL # MASTERED
1092	HARTLEY, JOHN F.	8	6	-2
1014	HOLDEN, ANDREA E.	2	4	+2
1560	LEVIN, PHILLIP A.	5	2	-3
1302	SPRECHER, GORDON B.	3	5	+2
1216	THIESEN, PAUL E.	7	5	-2
1534	WEBER, JULIE A.	7	4	-3

along with other personal, demographic, and standardized test data, becomes part of the data base and provides a valuable resource in the study of cognitive learning. The results of such research should find utility in improved diagnosis and prescription within CMI systems.

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